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CONTENT OF MACRO- AND TRACE ELEMENTS IN SWEET CHESTNUT PHYTOMASS IN BELASITZA MOUNTAIN, BULGARIA

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Abstract

The content of macroelements Ca, K, Mg and N, as well as of trace elements Fe, Mn, Cu, Zn and Pb has been studied in different phytomass fractions (leaves, bark, annual and perennial branches, catkins, cupolas, acorns, litter and mulch) and in soil horizons in three sweet chestnut communities – various in age and management activities in Belasitza mountain. The coefficient of biological absorption is calculated for all fractions and elements, and the elements turnover intensity is determined. Disturbances in studied functional parameters were determined, which is also connected with the observed health status of sweet chestnut forests in the mountain.

Key words: sweet chestnut forests, Belasitza mountain, macroelements, trace elements

INTRODUCTION

According to data collected from European countries, sweet chestnut forests in Europe cover 2 000 000 ha, and 80% of them are private (Amorini et al., 2000). On the Balkan Peninsula, the occurrence of sweet chestnut communities is in direct dependence from Mediterranean and Black Sea climatic influence (Le Houerou, 1992). In Bulgaria, the sweet chestnut areas cover 3356 ha (data from 2003), which is only 0.1% of the forest fund. In spite of the various hypotheses about the provenance of sweet chestnut in Bulgaria, it is considered for the present that only 500 ha of the forests are natural (Kochev, 1973; Dobrinov et al., 1992).

The degradation of sweet chestnut forests in Europe is considered to be a serious problem in the end of the 1970s. The main hypothesis for their poor condition, together with the global climatic changes and land use problems, is the predomination of ageing stands. *Castanea sativa* Mill. ecosystems have been an object of study within the projects 'Sustainability of Mediterranean ecosystems – case study of the chestnut forest, 1994-1997' and 'Multidisciplinary chestnut research – COST Action G4, 1998' (Romane, Grossman, 1997b; Heiniger et al., 2001). Even today the hard work for improvement of sweet chestnut forests continues in Western Europe.

The most serious threats for sweet chestnut communities today are in disease (*Phytophthora species*), bark cancer (*Cryphonectria parasitica* Murr. (Syn. *Endothia parasitica* Murr) and the spreading of *Loranthus europeus* L. (Bourbos, Metzidakis, 2000; Vannini, Vettraino, 2001; Heiniger et al., 2001; Petkov, Rossnev, 2001). Sweet chestnut is also attacked by other diseases and pests on bark, leaves and acorns. For example, fungi from genus *Melancolis*, the dangerous chestnut weevil (*Curculio elephas* Gyll.), etc. The spreading of diseases and pests depends on environmental, biotic (community and human) factors – utilisation and management.

During the last years, increasing interest is observed on the side of the society towards sweet chestnut, due to quality of timber, delicious acorns (with utilisation in food, pharmaceutical and cosmetics industries) and to the fact that communities are suitable for multifunctional management (Kitanov, 1986; Amorini et al., 2000; Bratanova-Doncheva et al., 2002).

Basic directions, on which it is being worked to reduce degradation processes, are: determination of ecosystem criteria (structure and functions of sweet chestnut communities) and biological criteria (creation of sustainable sorts through improvement and hybridization with *Castanea crenata* Sieb. et Zucc. and *Castanea mollissima* Bl.) for sustainability of communities, development of models for silvicultural intervention and way of utilisation and of pest control models.

Numerous works have been published, concerning spreading, biology and phytocoenology of the species, its ecological requirements, diseases and pests, ideas about establishment of sweet chestnut plantations, improvement, introduction and hybridisation of sustainable sorts (Zhelyazkov et al., 1980; 1982; Bratanova-Doncheva et al., 1995; 1998a,b; 2002; 2003; Marcelino et al., 2000; Queijeiro et al., 2000; Velev et al., 2000).

The dynamics of sweet chestnut ecosystems is very fast and, in absence of management, they turn into mixed deciduous forests, which is due to the invasion of shade tolerant broadleaved species (Conedera et al., 1998). Similar processes are observed in Western Balkan range – gradual replacement of sweet chestnut forests with *Fagus sylatica* L. and *Carpinus betulus* L. ones (Kochev, 1973; Lyubenova et al., 2002a,b; Bratanova-Doncheva et al., 2002).

In Bulgaria, sites of *Castanea sativa* Mill. are under special protection in the list of types of natural habitats of EU interest, which protection requires determination of 'zones under special protection' (type 9260 – Sweet chestnut forests) of Directive 92/43/EEC (Council Directives 92/43/EEC; Bratanova-Doncheva, 2003). According to the degree of threat, sweet chestnut refers to the category 'species threatened of extinction'.

The assessment of ecosystem criteria for sustainability of sweet chestnut forests requires profound complex studies on the structure and functioning of communities. For example, studies on biogeochemical turnovers have been carried out in Portugal by Pires et al., in Spain by Gallardo-Lancho et al. and Santa Regina et al., in Italy by Leonardi et al. and in France by Romane et al. (1997a,b).

The aim of this research is to make a comparative analyses of macro- and microelement content and some geochemical coefficients in different phytomass fractions and investigated communities.

The present investigation is part of a complex study on structural and functional parameters of sweet chestnut communities in Southwest Bulgaria and has the aim to lay the application of ecological management of sweet chestnut forests in Bulgaria on scientific fundaments.

OBJECT OF INVESTIGATION

According to Galabov (1982), Belasitza mountain is part of Rila-Rhodopes geomorphologic province, Macedonian-Rhodopean area; sub-area of Ruj-Belasitza mountain chain and Middle-Struma grabenova valley, Osogovo-Belasitza region. According to hydrology, the region refers to area A – with Mediterranean climatic influence on runoff; region A11 – Struma-Ograzhden. It is characterised with clearly expressed Mediterranean features, with typical main winter runoff maximum but also with influence of snow keeping on slopes with northern exposure. According to climate Belasitza mountain refers to continental-Mediterranean area (Velev, 2002).

According to the soil regioning of the country, the investigated region refers to the Mediterranean soil area, Balkan-Apennine soil sub-area, Osogovo-Belasitza mountain province. Mainly Dystric Cambisols, Rankers and Lithosols represent the soil cover. There is a limited number of terrains with Eutric Cambisols.

The geobotanical regioning refers Belasitza mountain to the European deciduous forest area, Macedonian-Thracian province, Belasitza district. The sweet chestnut formation refers to the nemoral vegetation, which main representatives are forest formations of deciduous tree species with spreading connected with the European deciduous forest area. Its optimum of spreading is connected with the belt of *Fagus sylvatica* L. – *Quercus petraea* Liebl. forests (600-1000 m a.s.l.). According to the water factor, the formation refers to the moesophytic ecological type (Bondev, 2002).

The characteristics of the investigated plots are shown in Table 1.

METHODS OF INVESTIGATION

From the three investigation plots, average samples were formed of different phytomass fractions (leaves, bark, annual and perennial branches, catkins, cupola, acorns, litter and mulch), as well as average samples from soil horizons for chemical analyses. Plant samples were dried to absolute dry weight and grinded to flour condition. It is used 1 g from the analysis, weighed on analytical balance. Soil samples were cleaned from big-sized roots, stones and other admixtures, dried to air-dry condition, grinded and screened through 2 mm bolter. For the analysis, 1 g sample was used, weighed on analytical balance. The total and nitrogen proteins were determined through the method of Kjeldahl (Bazilevich, Rodin, 1971).

The analytical determination of elements was carried out on atomic-absorption spectrometer PERKIN-ELMER 310A in Forest Research Institute at Bulgarian Academy of

Table 1
Characteristics of investigated plots

Index	P I	P II	P III
Area (ha)	0.25	0.20	0.20
Altitude	750	650	500
Slope	17	28	23
Exposure	NE	E	NW
Slope part	upper	lower	upper
Soil	Dystric Cambisols,	Dystric Cambisols,	Chromic Luvisols
Mechanical content	deep, rocky, light	middle deep, strongly rocky with more heavy earth-fine	middle deep, rocky,
Tree layer: Species Structure Bonitus	chestnut 10 two sublayers II	chestnut 10, beech 1 three sub-layers IV-V	chestnut 10 two sub-layers I
Origin	natural	natural	artificial
Age, y	45	180	45
Slope of tree layer	0.5 -0.7	0.3-0.8	0.7-0.9
Association	*Castanetum – Mixoherbosum*	*Castanetum – Mixoherbosum*	*Castanetum – Mixoherbosum*
Silviculture activities	Fellings 30 years ago	without	Fellings 30 and 15 years ago

Sciences after wet mineralisation of samples according to the requirements of ISO 11466.

The potentiometric method (ISO10390) was used to determine soil pH. The determination of pH in water extraction was carried out at correlation between sample and water 1:2.5. It was used 10g of air-dry soil screened through 2 mm bolter.

The litter coefficient was calculated after Vorobyov (1967), the coefficient of biological absorption (of biological absorption or vegetation-soil coefficient) of the investigated phytomass fractions, as well as acropetal coefficient (Perelman, 1975; Brucks, 1986).

RESULTS AND DISCUSSION

From the three analysed macroelements (Ca, K and Mg) in 12 phytomass fractions (leaves, annual branches, 4 groups of perennial branches, catkins, acorns, cupola, grass phytomass, stem mosses and lichens) average for the three investigated chestnut communities it was established predomination of Ca from 28.3x10^{-3} mg/kg in the bark (Table 2) to 0.8x10^{-3} mg/kg in perennial branches with diameter between 5 and 10 cm (Fig.1) and K from 8.7 to 0.8x10^{-3} mg/kg (Fig. 1).

Ca predominates in fractions of bark, catkins, cupola, grass phytomass, annual branches, acorns, lichens and perennial branches up to 1 cm, and its content decreases from 28.3x10^{-3} mg/kg in the bark to 2.6x10^{-3} mg/kg in the phytomass of perennial branches up to 1 cm (Table 2).

In the same fractions the content of K is highest in the acorns – 2.8x10^{-3}mg/kg and minimal in bark (0.9x10^{-3} mg/kg). The content of Mg is highest in grass phytomass 1x10^{-3} mg/kg) and minimal (0.22x10^{-3} mg/kg) in lichens phytomass (Table 2).

The content of all three elements is highest in leaves phytomass. K takes first position according to content in leaves fraction, stem lichens and the three groups of perennial branches – with diameter: 1-2 cm; 2-5 cm and 5-10 cm. This content is relatively high in the stem lichens fraction as well. The content of the elements decreases from 8.7x10^{-3} mg/kg in leaves to 0.8x10^{-3} mg/kg in the fraction of perennial branches with d

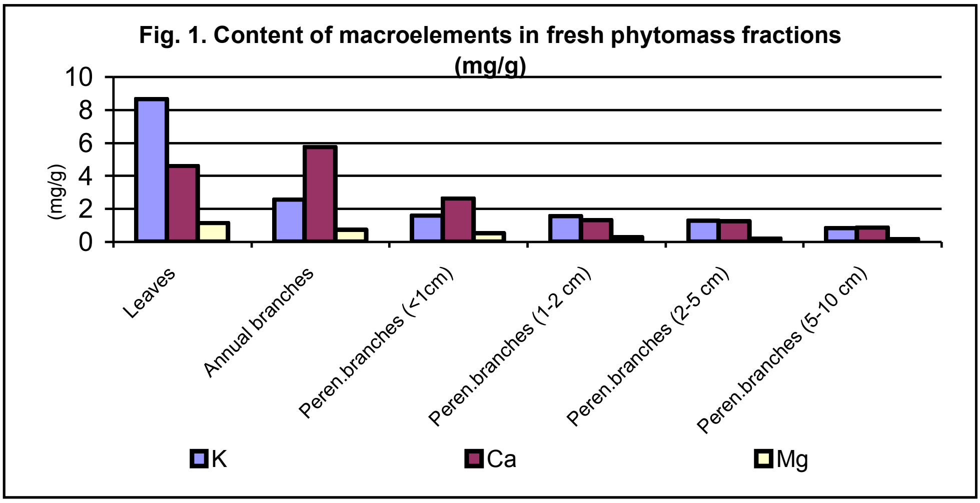

Fig. 1. Content of macroelements in fresh phytomass fractions (mg/g)

Table 2
Distribution of macroelements in phytomass fractions

Fraction	**Elements (x10^{-3} mg/kg):**		
	Ca	> K >	Mg
bark	28,3	0,9	0,5
tassel	9,9	1,3	0,7
cupola	6,4	1,9	0,7
herbs	6,4	1,9	1,0
annual branches	5,8	2,5	0,7
acorns	4,7	2,8	0,6
stem lichens	4,5	1,7	0,2
peren. branches (<1 cm)	2,6	1,6	0,5

= 5-10 cm. The same order is observed in the decreasing of content of Ca (from 4.6 to $0.8x10^{-3}$ mg/kg) and Mg (from 1.1 to $0.2x10^{-3}$ mg/kg) as well.

Together with the ageing of leaves (in the leaves of litter-fall), the content of K decreases from 3.8 (2nd community), 2.4 (1st) and 2.1 times (3rd) respectively, and the content of Ca decreases from 2 (2nd community), 1.8 (1st) to 1.6 times (3rd), respectively. The content of K decreases in highest degree and, respectively, the content of Ca increases in highest degree in community 2. The quantity of Mg decreases from 1.8 (2nd) to 1.4 times (1st and 3rd) in leaves of litter-fall. Meanwhile, increased content of N was recorded in old leaves, which replaces Mg from the 3rd position in regressive rows: from $8.1x10^{-3}$ mg/kg (1st community), $7.8x10^{-3}$ mg/kg (2nd) and $5.9.10^{-3}$mg/kg (3rd). The nitrogen predominates in strongest way in leaves fraction of 1st and 2nd community and is 1.4 to 1.3 times less in 3rd community (Table 3).

In the perennial branches of the litter, compared to their fresh fractions, the content of K (to contrast of leaves fractions) increases 3 times, and this of Ca decreases 1.4

Table 3

Distribution of macroelements in litter-fall fractions

Fraction	Elements (x10-3 mg/kg):		
	K>	Ca	>Mg
leaves	8.7	4.6	1.1
stem lichens	3.7	3.3	0.7
peren. branches d =1-2 cm	1.6	1.3	O.3
peren. branches d =2 -5 cm	1.3	1.3	0.2
peren. branches d =5-10 cm	0.8	0.8	0.2

times average. First position, according to average content in this fraction, is taken by N ($6.2x10^{-3}$ mg/kg).

By comparative investigation of average content of all 9 studied elements in the 6 fractions from the litter, the following regressive rows could be formed:

Bark: Ca > N > K > Fe > Mg ≈ Mn > Zn > Cu ≈ Pb

Tassel: Ca > N > K > Fe > Mn > Mg > Zn > Cu ≈ Pb

Leaves: Ca > N > K > Fe ≈ Mg ≈ Mn > Zn > Cu > Pb

Peren.
branches: Ca > N > Fe > Mn > K ≈ Mg > Zn > Cu ≈ Pb

Acorns: N > Ca > K > Fe > Mg > Mn > Zn > Pb > Cu

Cupola: K > Ca > N > Fe > Mg > Mn > Zn > Cu > Pb

As it can be seen, the Ca quantity is highest in the first 4 fractions, and according to content it takes second position in acorns and cupola. From first to sixth fraction its quantity decreases from 22.6x10^{-3} mg/kg in the bark to 4.1x10^{-3} mg/kg in cupola. On second place in most of the studied fractions, according to content, is N. It takes first position in the regressive row of acorns and third position in the cupola. Its average content is highest in the catkins (8.0x10^{-3} mg/kg), followed by leaves and bark (7.3 and 7.2x10^{-3} mg/kg), perennial branches and acorns (5.3x10^{-3}mg/kg) and is least in cupola (2.3x10^{-3} mg/kg). Highest content of K was determined in cupola (9.2x10^{-3} mg/kg average), where it takes first place in the regressive row. In most rows, however, it takes third position with content 3.5; 3.4; 3.3 and 1.3x10^{-3} mg/kg, respectively. Its average content is lowest in perennial branches – 0.9x10^{-3} mg/kg, where it takes fifth position in the regressive row.

The determined average content of Fe is highest in the perennial branches fraction (4.3x10^{-3} mg/kg), where it takes third position in the regressive row. In the rest fractions its content varies from 2.1x10^{-3} mg/kg in acorns and 1.9x10^{-3} mg/kg in catkins to 1.2x10^{-3} mg/kg (bark and cupola) and is lowest in leaves – 0.8x10^{-3} mg/kg. The determined average Fe content in investigated fractions is much over the minimal concentration level for plants, given by Marshner (after Lyubenova, 1999). The Fe content in all studied fractions is above the **c**lark (average content) of phytomass (Vinogradov, after Lyubenova, 1999), and it exceeds it from 8 to 43 times.

According to their average content in phytomass fractions, Mg and Mn take 5th and 6th position in the regressive rows of bark, catkins, leaves, acorns and cupola. The average Mg content is big in the catkins, perennial branches and cupola (1; 0.9 and 0.8x10^{-3} mg/kg, respectively) and is less in acorns and bark (0.7 and 0.6x10^{-3} mg/kg, respectively). The Mn average content is higher in catkins and perennial branches (1.5 and 1.1x10^{-3} mg/kg, respectively) and is less in leaves, bark and cupola (0.8; 0.6 and 0.4x10^{-3} mg/kg, respectively). The determined average Mn content in studied fractions is over for the phytomass clark (Vinogradov, after Lyubenova, 1999). It is much over the minimal concentration level for plants but below the maximal toxic concentration level (Edwards, Asher, after Lyubenova, 1999).

According to specific average content, Zn takes definitely 7th position in the regressive rows of the investigated fractions. Its average content varies from 0.5x10^{-3} mg/kg (bark and catkins), 0.4x10^{-3} mg/kg (perennial branches) to 0.3x10^{-3} mg/kg (leaves, acorns, cupola). The determined content is over the clark of phytomass, cited by Vinogradov (after Lyubenova, 1999) and is on the limit and above the maximal concentration level for polluted areas (Jones, after Lyubenova, 1999). In all fractions (with the exception of leaves, acorns and cupola), the average Zn content is over the critical toxic level for the biomass.

The last two positions (8th and 9th) in the regressive rows of the specific average content of elements are taken by Cu and Pb. In most fractions Cu takes 8th position. Its average content varies from maximal – 0.009x10^{-3} mg/kg (catkins), where it exceeds the determined phytomass clark, to 0.0007x10^{-3} mg/kg (catkins and perennial branches) and 0.006x10^{-3} mg/kg (bark and leaves) to its minimal quantity – 0.005x10^{-3} mg/kg in acorns, where it is below the phytomass clark. The average Pb content is very high in acorns – 0.07x10^{-3} mg/kg (8th position). In the rest fractions it varies from 0.007x10^{-3} mg/kg (catkins and perennial branches) to 0.006 (bark), 0.005x10^{-3} mg/kg (leaves) and 0.003x10^{-3} mg/kg (cupola).

Higher content of the elements in phytomass of seed forest was established (towards the calculated average values for each fraction from the three communities) by most fractions and elements. For example, the content in fractions of perennial branches and acorns is higher for 7 elements (from 9 investigated), in the bark – for 6 elements and for catkins – for 5 elements. The content of most elements is less only for cupola (5 elements) and leaves (6 elements) of the seed forest (Table 4).

By the arrangement of elements according to relative content in the litter and mulch, the following regressive rows appear (Table 5):

Litter-fall: Ca > K > Fe > Mn > Mg ≈ Zn > N > Cu > Pb

Mulch: Ca > N > K > Fe > Mn ≈ Mg > Zn > Pb > Cu

The specific content of elements in mulch and litter is close to the determined in the bark.

Ca and K have relatively high content, which is higher in the mulch towards the content in litter – for Ca (19, 5 and 8.8 times) and for K (5.9 and 2.6 times). The determined Ca content in the mulch and litter is higher than the phytomass clark, and of K – much below the average phytomass content.

The content of N in the mulch (towards bark) decreases 2 to 3 times and takes second position in the regressive rows, and the content in the litter decreases 1200 times and takes 7th position in the relevant regressive row.

The specific Fe content (third and fourth position) increases in mulch and litter, and its average content is higher in mulch (1.8x10^{-3} mg/kg) towards litter (1.3x10^{-3} mg/kg) and bark (0.8x10^{-3} mg/kg) and it is much over the minimal biomass concentration level (Marshner, after Lyubenova, 1999) and the determined biomass clark.

The content of Mn and Mg is almost equal in all three fractions (1x10^{-3} mg/kg for mulch; 0.7x10^{-3} mg/kg for litter and 0.6x10^{-3} mg/kg for bark, respectively), and decreases gradually in mulch and bark in the phytomass of first and third communities. It is over the average content of phytomass and over the lower maximal toxic concentration level (Edwards, Asher, after Lyubenova, 1999).

The content of Zn in litter and mulch (0.4,10^{-3} mg/kg) is slightly decreased towards bark (0.5x10^{-3} mg/kg).

The content of Cu and Pb does not change very much in all three fractions. It is higher than the average content of K, Fe, Mn, Mg, N, Cu и Pb in the litter of seed forest, and in the mulch for Fe, Mn, Mg, Zn, Pb and Cu, respectively.

The content of investigated elements in the litter increases in the phytomass of community 2 towards 3 and 1. The only exception is Ca, which content is highest in the mulch of community 1 (Fig.2).

The same trend is observed according to the investigated elements in the forest mulch – their content is highest in the phytomass of the seed forest. Only two elements make an exception in this case – Ca and N, which content is maximal in the phytomass of the first investigated community, and in the second and third their content decreases.

Table 4
Regressive content row of elements in studied fractions and communities

Fraction x10^{-3} mg/kg	**Regressive content row**								
Bark	**Ca >**	**N >**	**K >**	**Fe >**	**Mg ~**	**Mn >**	**Zn >**	**Cu ~**	**Pb**
Average	**22.6**	**7.2**	**1.3**	**0.8**	**0.6**	**0.6**	**0.5**	**0.006**	**0.006**
II	11.3	15.7	2.1	1.2	0.8	1.3	0.4	0.007	0.004
I	28.3	2.1	0.9	0.4	0.5	0.3	0.8	0.007	0.005
III	28.2	3.7	0.8	0.7	0.4	0.3	0.3	0.003	0.008
Tassel	**Ca >**	**N >**	**K >**	**Fe >**	**Mn >**	**Mg >**	**Zn >**	**Cu ~**	**Pb**
Average	**9.0**	**8.0**	**2.0**	**1.9**	**1.5**	**1.0**	**0.5**	**0.007**	**0.007**
II	11.9	8.3	3.5	0.4	1.6	1.2	0.6	0.005	0.005
I	9.9	10.6	1.4	4.0	2.3	0.7	0.5	0.007	0.013
III	5.2	5.2	1.2	1.3	0.7	1.0	0.3	0.009	0.004
Leaves	**Ca >**	**N >**	**K >**	**Fe ~**	**Mg ~**	**Mn >**	**Zn >**	**Cu >**	**Pb**
Average	**8.2**	**7.3**	**3.4**	**0.8**	**0.8**	**0.8**	**0.3**	**0.006**	**0.005**
II	9.0	7.8	2.3	0.5	0.6	0.2	0.2	0.007	0.000
I	8.2	8.1	3.7	0.9	0.8	0.7	0.3	0.005	0.005
III	7.5	5.9	4.1	1.2	0.8	1.4	0.4	0.005	0.009
Peren.branches	**Ca >**	**N >**	**Fe >**	**Mn >**	**K ~**	**Mg >**	**Zn >**	**Cu ~**	**Pb**
Average	**6.3**	**5.3**	**4.3**	**1.1**	**0.9**	**0.9**	**0.4**	**0.007**	**0.007**
II	10.4	5.6	6.7	2.0	1.2	1.3	0.6	0.011	0.012
I	1.1	6.2	0.2	0.2	0.1	0.4	0.1	0.004	0.000
III	7.5	4.1	5.9	1.2	1.4	0.9	0.4	0.005	0.009
Acorns	**N >**	**Ca >**	**K >**	**Fe >**	**Mg >**	**Mn >**	**Zn >**	**Pb >**	**Cu**
Average	**6.1**	**5.3**	**3.3**	**2.1**	**0.6**	**0.4**	**0.3**	**0.007**	**0.005**
II	5.9	9.1	2.7	1.9	0.7	0.3	0.4	0.008	0.005
I	5.9	4.7	2.8	4.0	0.6	0.7	0.2	0.000	0.004
III	6.5	2.1	4.3	0.3	0.4	0.2	0.2	0.2	0.005
Cupola	**K >**	**Ca >**	**N >**	**Fe >**	**Mg >**	**Mn >**	**Zn >**	**Cu >**	**Pb**
Average	**9.2**	**4.1**	**2.3**	**1.2**	**0.7**	**0.4**	**0.3**	**0.009**	**0.003**
II	24.5	3.3	2.1	2.8	1.0	0.3	0.4	0.017	0.010
I	1.9	6.4	1.8	0.5	0.7	0.5	0.4	0.006	0.000
III	1.3	2.7	3.0	0.2	0.4	0.4	0.1	0.003	0.000

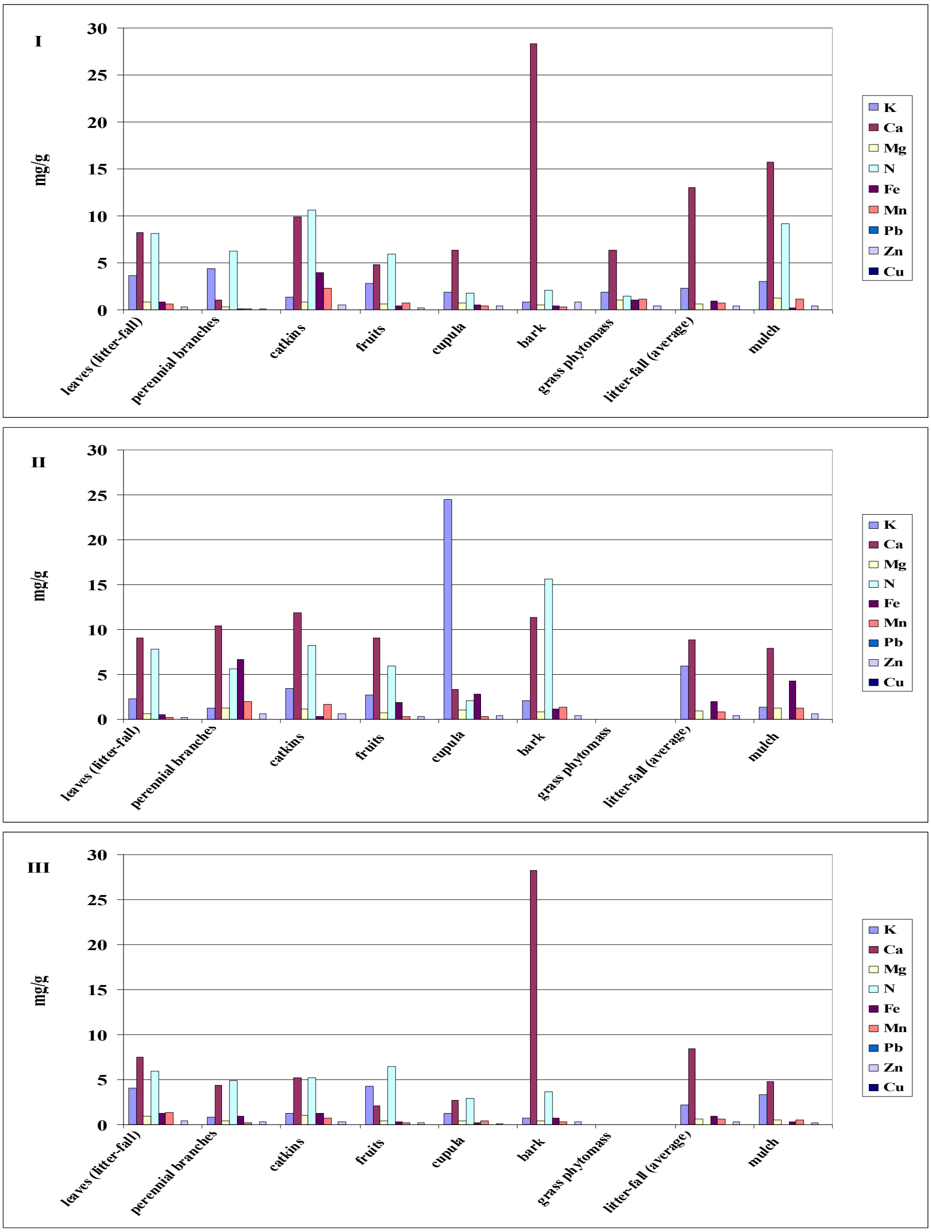

Fig. 2. Content of macro and trace elements in litter-fall of studied communities

According to determined parameters, soil in studied communities is in cited norms for Dystric Cambisols – poor in organic (1600 – 1900x10^{-3} mg/kg total N), with slightly acid reaction (pH from 6.1 to 6.45). The determined quantities of Fe and Pb in humus horizon of soils of all three phytocommunitiess, where the most of the plants' roots are situated, are within the range of the clark of soils (Vinogradov, after Lyubenova,

Table 5
Regressive content row of elements of litter-fall and mulch in studied communities

Fraction x10^{-3} mg/kg	Regressive content row								
Litter-fall	**Ca >**	**K >**	**Fe >**	**Mn ~**	**Mg >**	**Zn >**	**N ~**	**Cu >**	**Pb**
Average	**10.1**	**3.5**	**1.3**	**0.7**	**0.7**	**0.4**	**0.006**	**0.006**	**0.005**
II	8.8	5.9	2.0	0.9	1.0	0.4	0.007	0.008	0.006
I	13.1	2.3	1.0	0.7	0.6	0.4	0.006	0.005	0.005
III	8.4	2.2	1.0	0.6	0.6	0.3	0.006	0.005	0.005
Mulch	**Ca >**	**N >**	**K >**	**Fe >**	**Mn ~**	**Mg >**	**Zn >**	**Pb >**	**Cu**
Average	**9.5**	**3.1**	**2.6**	**1.8**	**1.0**	**1.0**	**0.4**	**0.006**	**0.005**
II	8.0	0.008	1.4	4.2	1.3	1.2	0.6	0.010	0.007
I	15.8	9.2	3.1	0.2	1.1	1.3	0.4	0.005	0.004
III	4.8	0.011	3.3	0.3	0.5	0.6	0.2	0.002	0.003

1999). The content of Mn, Cu and Zn is far below the utmost allowed concentration for soils at the relevant acidity (Instruction Nr. 3/1979) and below the determined clark.

The coefficient of biological absorption of macroelements like Ca is the highest in all sample plots (or communities) and for all fractions (Fig. 3). In community 1 the coefficient reaches higher values and changes more strongly. Its minimal value is about 1 in the grass area and reaches up to 68 in the crown of the edificatory species, which is the absolute maximum of the determined coefficient of biological absorption for all elements and investigated fractions. In the seed forest (community 2) the coefficient of biological absorption of Ca is minimal in the perennial branches with diameter over 5 cm (about 1) and maximal in catkins (about 15), i.e. the most Ca quantity is accumulated in this fraction. The coefficient of its biological absorption in the third investigated community changes from about 1 (in the phytomass of branches with diameter over 5 cm) to about 44 (in edificator's bark). This phytocoenosis takes intermediate position according to destabilisation degree of Ca turnover. The coefficient of biological absorption decreases by growing of the diameter of perennial branches from 6 to 2, from 13 to 1 and from 4 to 1, respectively, in the first, second and third community for branches with diameter below 1 cm to these ones with diameter 5-10 cm.

The determined coefficient of biological absorption of K has much lower values than that of Ca and changes more slightly in all three sample plots. For many phytomass fractions the K-coefficient is below 1. In the first investigated community it changes from 1 in the fractions of annual branches, acorns, cupola and catkins to 4 in the leaves fraction. Its interval of change in the seed forest (community 2) is slightly bigger – from 1 (annual branches, acorns and bark) to maximum 12 in cupola. The third community takes again intermediate position according to interval of coefficient varying and to number of fractions with determined coefficient over 1. The value of biological absorption in the stem lichens is minimal, and in the foliar phytomass – maximal.

Mg is poorly absorbed in the phytomass of investigated sweet chestnut communities – the number of fractions with coefficient over 1 decreases, as well as the value of coefficient and its range of change in different fractions. The minimal value of the coefficient is about 1 in all three investigated communities for stem lichens (1st, 2nd communities), annual branches and acorns (2) and perennial branches (3). The maximal value of the coefficient is 2 for the first (in grass and foliar phytomass) and second (in leaves, cupola, bark and litter of perennial branches) sample plots and 3 for the third one (in foliar phytomass).

The coefficient of biological absorption of N is below 1 for all investigated fractions (with the exception of the litter of perennial branches in the third sample plot, where it is about 3), i.e. the content of the element there is lower than its quantity in soil. This fact shows destabilisation of biological turnover in the investigated sweet chestnut ecosystems.

The coefficients of biological absorption of trace elements (Fig. 4) in different fractions vary most strongly in the first community. Highest values are calculated for Zn – from 4 (acorns and branches) to 20 (bark). In the seed forest (community 2) the interval of changing and maximal values of the coefficient are less. Its minimal value is 8 (for acorns and bark), and the maximal one is 14 for perennial branches and catkins. According to coefficient values and interval of changing, the phytomass in the third community takes intermediate position. The coefficient of biological absorption of Zn is minimal in the cupola (Ax = 4) and maximal (Ax = 11) for the catkins and perennial branches.

The coefficient of biological absorption is under 1 for the trace elements Fe, Pb and Cu, with the exception of cupola in seed forest, which accumulate Cu. The absorption of Mn is also poor. In the first sample plot, the coefficient for acorns, catkins and grass phytomass is 1, 2 and 4, respectively, and in the second one it is over 1 only for the fraction of branches.

The total volume of macroelements in the mulch is 366.35 t/ha. In the seed forest and in third community volume is almost equal –130.96 t/ha and 131.29 t/ha, respectively. The volume in the first community is lower – 104.03 t/ha. The quantity of elements in the first mulch layer predominates, and only in the first community the Ca quantity is higher in the second layer. Basic quantities of investigated elements in litter are concentrated in foliar fractions and cupola, and in the seed forest – in foliar fractions, branches and cupola.

N participates with highest percentage in total volume of macroelements in all investigated communities – total 64.08%. Ca is on second place with 16.52%, followed by K – 15.64%. The percentage of Ca in mulch in the third community is about twice higher than this one of K. In the first and second ones the share of K is bigger. The participation of Mg is least in the total volume of macroelements in mulch – 3.76%. Its quantity is lowest in the second and third community – 1.42 and 3.99 t/ha, respectively.

The volume of elements in mulch is regenerated through the litter with 346, 17 t/ha per year. In the first community the annual litter includes 101.1 t/ha macroelements,

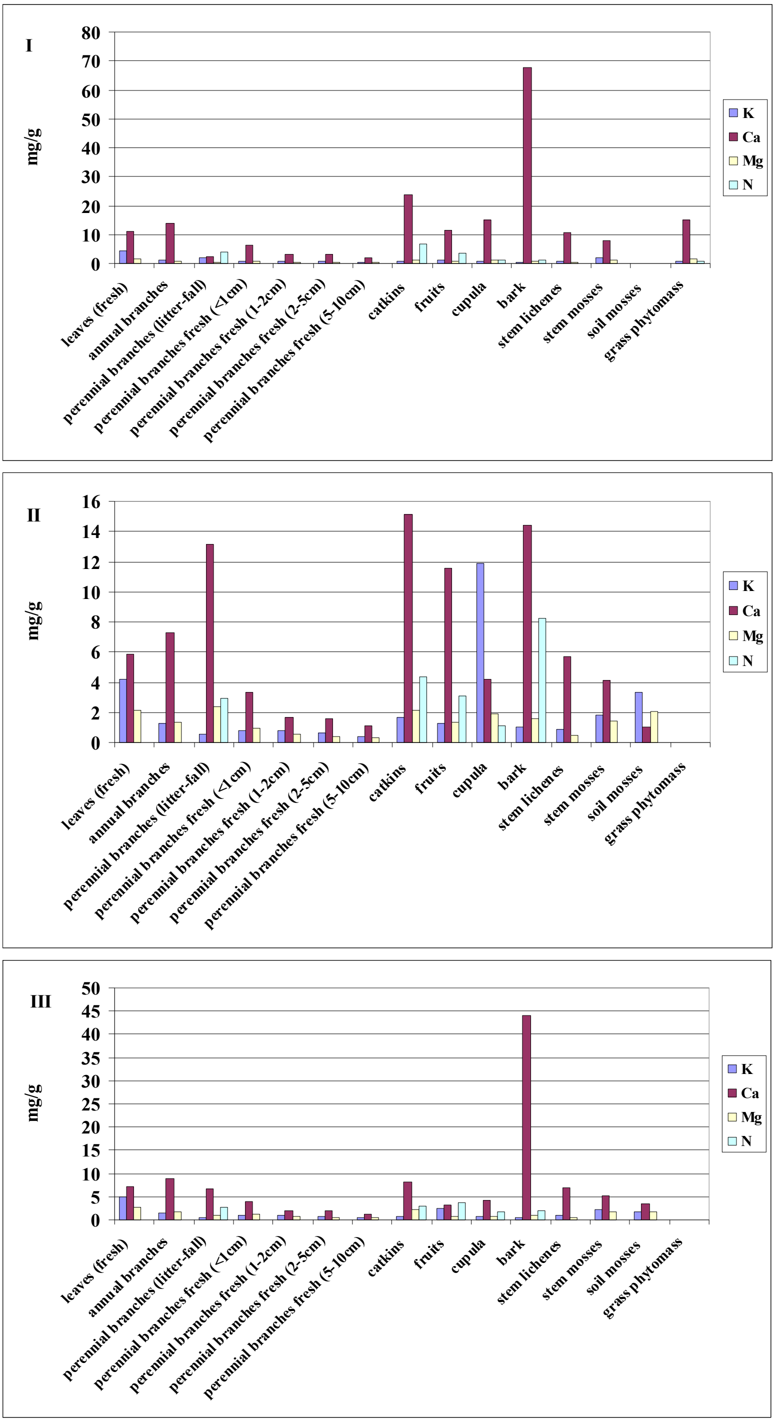

Fig. 3. Biological absorption coefficient of studied macroelements and fractions from investigated communities

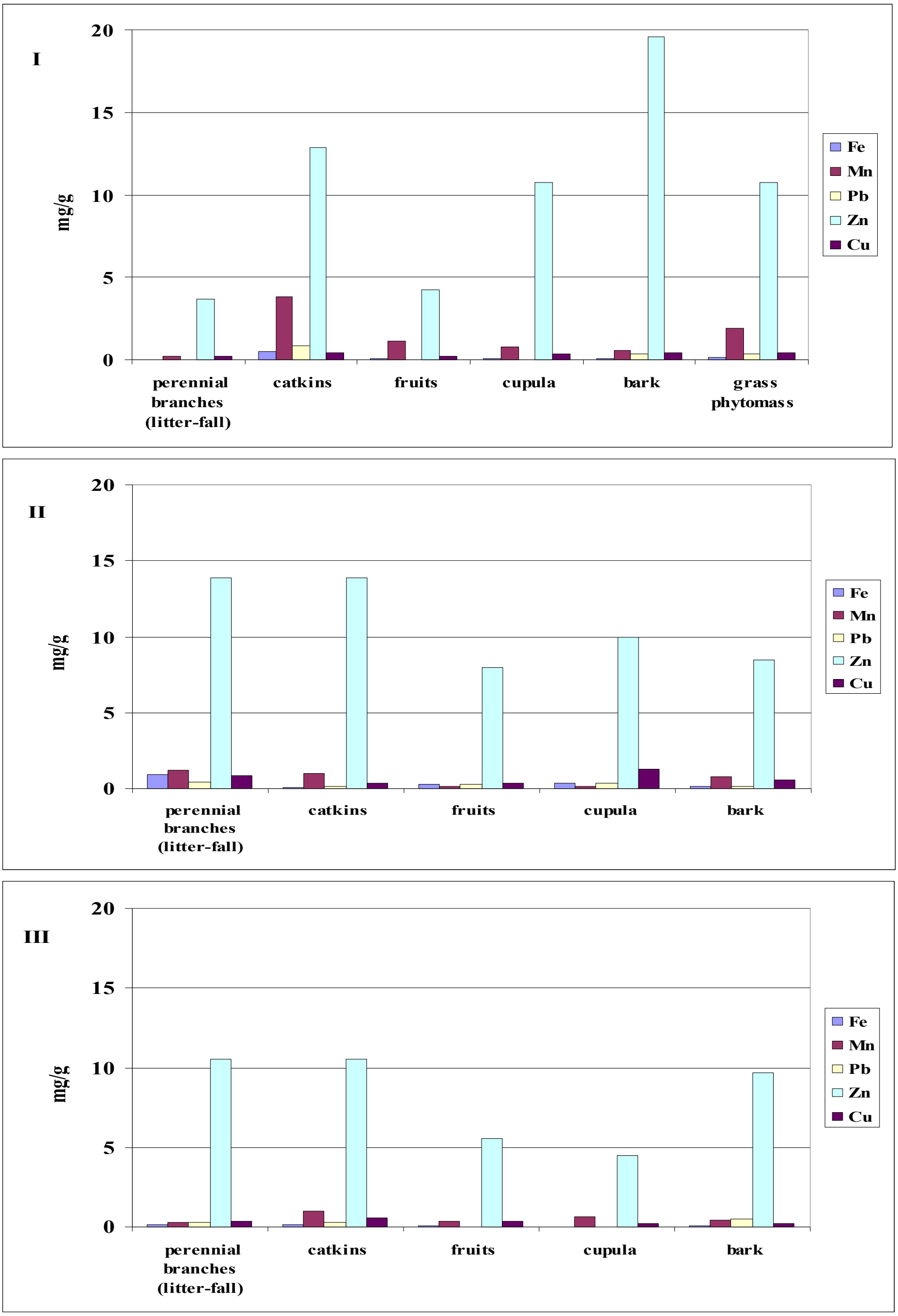

Fig. 4. Biological absorption coefficient of studied microelements and fractions from investigated communities

and in the second and third ones it is less – 68.88 and 40.72 t/ha, respectively. Basic quantities of investigated elements in the litter are concentrated in foliar fractions and cupola, and for the seed forest – in foliar fractions, branches and cupola.

N predominates also in the litter with 57.1% of the total volume of macroelemnts, followed by Ca – 27.26%, K and Mg – 12.63% and 3%, respectively. Predomination of Ca over N is observed in the litter in the first community – 12.27% and 10.6%, respectively. The quantitative share of these two elements in the seed forest is almost equal.

The total volume of trace elements in mulch is 93.12 t/ha. It is highest in the seed forest – 73.86 t/ha, in the first community is 73.86 t/ha and the least value is in the third one – 17.52 t/ha. The quantity of elements in the first mulch layer predominates, and only in the first community the quantity of Cu, Zn and Pb is higher in the second layer.

Fe participates with highest percentage in the total volume of macroelements – total 58. 78%. It is on first place according to percentage in the total volume and in the seed forest – 54.48%. Mn is on second place with 28.51%, followed by Zn – 12.39%. The percentage of Mn in the mulch in first and third community is highest, and this one of Zn is on second (1) or on third place (3). The quantity of Pb (0.18%) and Pb (0.13) is lowest in the total volume of trace elements in mulch.

Volume of trace elements in mulch is regenerated through the litter with 24.43 t/ha per year. In the first community the litter includes 9.16 t/ha of trace elements, and in the second and third ones it is less – 6.73 and 8.54 t/ha, respectively. Basic quantities of investigated trace elements in litter are concentrated in foliar fractions and cupolas, and in the seed forest – in foliar fractions, branches and cupolas.

Fe also predominates in litter – 49.04% of the total quantity of trace elements, followed by Mn – 34.59%. The participation of Zn in litter is considerable – 15.84%. Total quantities of Cu and Pb are almost equal – 0.29% and 0.25% of the total volume. The participation of Fe in the litter of first and second community is predominating, while in the third one this is Mn. The quantitative participation of Mn and Zn in the seed forest is lowest.

The total intensity of biological turnover of macroelements in sweet chestnut phytocommunitiess is 1.06. The turnover is intensive, of seventh rank. The slowed down turnover of 6th rank, with coefficient between 1.6 and 5, is typical for the deciduous forest communities (after Vorobyov, 1967). Acceleration of the turnover of K is observed in first and second community and of Ca, Mg and N – in the third. The N turnover in it is mostly disturbed – intensive, rank 8.

The total intensity of the biological turnover of trace elements in sweet chestnut phytocommunitiess is 3.81. The turnover is slowed down, of rank 6. This type of turnover is typical for the deciduous forest community (Bazilevich, Rodin, after Vorobyov, 1967). During the present investigation of the intensity of turnover of different elements it was established, that there is a disturbance towards acceleration or slowing down for some of them in different communities, which shows their destabilisation. For example, slowing down of the turnover of Fe and Mn (strongly slowed down, of 4th rank) and of Pb and Zn (strongly slowed down, of 5th rank) was recorded in the seed forest. In the first community the turnover of Fe (intensive, 8th rank), Pb and Cu (intensive, 7th rank) are accelerated. Accelerated turnover for 4 trace elements were recorded in the third community, as well. The turnover is intensive, 8th rank for Fe and Pb and 7th rank for Mn and Zn.

CONCLUSION

First three positions of macroelements for most of the investigated fractions are taken by Ca, N and K. This responds to the Ca chemist type of biological turnover, typical for deciduous forest communities, where Ca has the leading role and N and K are accompanying elements. Exceptions are acorns and cupolas, where the first position is taken by N and K, respectively, and the litter, where N is replaced by Fe as accompanying element.

By comparison of the content of some of the investigated trace elements (Cu, Pb, Zn) in the fractions (leaves, perennial branches, bark, acorns) in studied regions in Belasitza Mt. and Berkovitsa (Lyubenova et al., 2002a,b), higher content in all fractions from Belasitza Mt. was established. The only exception was Cu content in bark and acorns (0.011 and 0.009×10^{-3} mg/kg) and Pb in bark (0.008×10^{-3} mg/kg). Drastic increase of Zn content in all investigated fractions from Belasitza Mt. is observed.

By comparison of the obtained values of investigated macro- (K, Ca, Mg, N) and trace elements (Fe, Zn, Cu, Pb) for Belasitza Mt. with data from studies on oak forests carried out in different localities in Bulgaria (Lyubenova, 1999), increased content of N, Fe and Zn is observed in fractions (leaves, perennial branches, bark, acorns) of sweet chestnut.

Higher content was recorded for most of the investigated elements and fractions in the phytomass of the seed sweet chestnut forest. For example, for the fractions of perennial branches and acorns the content is higher for 7 elements (from 9 investigated), in the bark – for 6 elements and for the catkins – 5 elements. The content of most elements is lower only for cupolas (5 elements) and leaves (6 elements) of the seed forest towards other investigated communities.

The coefficient of biological absorption is over 1 for Ca in all fractions of all three investigated communities. For Mg it is over 1 for bark and catkins fractions in all three communities; for cupolas and bark in community 1 and 2; for soil lichens in community 2 and 3; for acorns in second sample plot for stem lichens and mosses in community 1. For K the coefficient is over 1 in leaves, annual branches and acorns in all three communities, for the litter of perennial branches and soil mosses in first community; for catkins, cupolas and bark in second one; for stem lichens and mosses and soil mosses in community 3. The coefficient of biological absorption of N and Zn is over 1 for the litter of perennial branches, catkins, acorns, cupolas and bark in all three investigated communities and in the grass of community 1. For Mn coefficient over 1 is calculated in the litter of perennial branches (community 2), in catkins, acorns and grass (community 1), and for Cu – only in cupolas in community 2.

During the present study, disturbance in the macroelements turnover towards acceleration was established, and for trace elements – towards slowing down, which brings to destabilisation of forest communities. These changes refer to 4 elements in the first community, 5 elements in the second and 6 elements in the third one. Increasing of the intensity of K, Fe, Cu and Pb turnover (intensive – 7th rank) was established in the first community, and of Ca, Mg, Mn, Fe, Zn and Pb – in the third one (intensive – 7th or 8th rank). The intensity of turnover of Mn, Fe, Zn and Pb in the second community is decreased (strongly slowed down turnover of 4th or 5th rank), and this one of K is increased (intensive turnover of 7th rank). These functional disturbances bring to destabilisation of sweet chestnut community and to decreasing of their resistance to diseases, parasites and insect pests.

Basic reasons for these disturbances in the context of the investigated tree species are complex – climatic fluctuations, anthropogenic factors (pollution, recreational overloading, etc.), as well as the growing of the endogenic succession potential by absence of sylvicultural management of forests.

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